Vegetable, mineral or animal?

Curious concentric circles in Shawangunk quartzite, on Kittatinny Mountain, N. J., which have received a wide variety of interpretations

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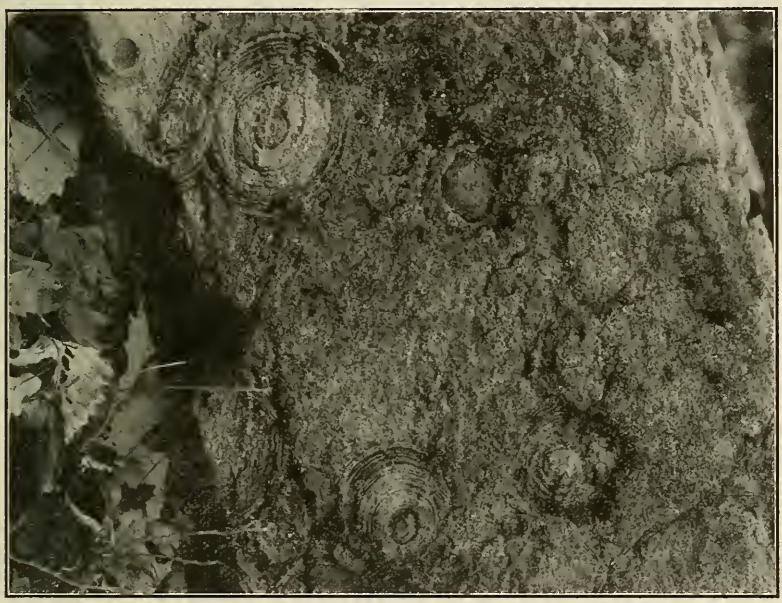
There is one chance in three that the objects described in this article may have been of vegetable origin, and as the editor of Torreya has offered me an opportunity to describe them, this account is presented in a botanical journal. I do not offer any positive explanation, but tell what I found and what others thought of them. Perhaps this will bring out further views which may clear the matter up.

While working on the Appalachian Trail, on Kittatinny Mountain, in Warren County, New Jersey, above five miles northeast of Delaware Water Gap. two summers ago, with Louis W. Anderson, of Elizabeth, N. J., our course was diverted from an older trail by the devastation of a recent forest fire to seek a better route along the edge of the wet swale known as Tock's Swamp, from which Tock's Run drops steeply down to the Delaware River. Beside this swamp, along what is now marked as the Appalachian Trail, was a large oblong boulder, about eight feet long, a foot or two through, and three or four feet out of the wet soil, in which half of it was probably buried. Anderson's eye first caught, and he called to me to see, a number of concentric rings on both faces of the boulder. The photographs in the illustrations of this article, made by Anderson, show them very well.

It seemed to me they must be fossils of some sort, from the regularity of the concentric structure. I recalled the pictures I had seen in some of the New York State Museum Reports, about 1917, of the similar circles in Cambrian limestone in the Mohawk Valley, particularly in Lester Park, near Saratoga, N. Y., which have been called *Cryptozoon proliferum*, and are believed by many paleontologists to be fossils of Cambrian lime secreting algae. But the boulder in which the rings at Tock's Swamp occurred is of the hard quartzose rock, known as Shawangunk Grit or Shawangunk Quartzite, a Silurian formation, which caps the Shawangunk and Kittatinny Mountains, from Mohonk Lake in Ulster County, N. Y., southwest through

northwestern New Jersey and along the Blue Mountain of Pennsylvania. Re-reading of the New York State Museum reports showed that no fossils had ever been reported in this formation, other than a few graptolites, in intercalated shales near Otisville, N. Y.

I thought we had found something new. First, I sent Anderson's photographs to Dr. Rudolf Ruedemann, New York State Paleontologist, at Albany. He was much interested, and wrote me:



"I am very much interested in the excellent photographs by Mr. Anderson of the problematicum. They leave no doubt that the fossil is more than mere weathering marks. It agrees in so many features with Cryptozoon as it occurs near Saratoga that I believe it may prove to be that calcareous alga. The occurrence of a Cryptozoon in the Shawangunk grit is not known and if turns out to be one, it should be published." He asked for chips of the material, for the purpose of making thin specimens, but after we had chiselled a complete circle, with a dozen rings, out of the boulder, on another visit, and sent it to him, he doused my hopes of locating a new fossil where it had no business to be, by writing:

"The interesting fossil from Kittatinny Mountain does not seem a Cryptozoon after all. While Cryptozoon is a calcareous alga, this specimen consists of quartz grains. I considered it possible that the quartz might be pseudomorphous after calcite, but Mr. Newland [Mr. D. H. Newland, State Geologist of New York] assures me that the fossil is composed of true sand-grains, or has the same composition as the matrix. It therefore seems that the body must have been a mud-ball such as are found in

sandstone, and that the clay or lime or whatever held the sand-grains together has been dissolved out. Such balls form on the bottom of rivers and shores with sandy bottoms. The concentric shells are so regularly spaced that the thing is most deceptive. It is really too bad that it is not a cryptozoon, it would be such an interesting find."

Meanwhile I had written to Dr. Marshall A. Howe, Assistant Director of the New York Botanical Garden, who is an authority on living and fossil algae and who has described somewhat similar ring-like formations as undoubted fossil algae, in shales and limestones. Dr. Howe seemed to think it possible that the Kittatinny "problematicum," both from photographs

and the same specimen sent to Dr. Ruedemann, was a fossil alga, probably a Cryptozoon, which deserved a new specific name. In our further correspondence, we had almost agreed on such a name, as *Cryptozoon kittatinyense*, or *concentricum*. Referring to Dr. Ruedemann's conclusion that it was a mud-ball, Dr. Howe said:

"It is hard for me to believe that a thing of this sort is not organic. However, I do not like to describe things as fossil algae unless they show some microscopic cell structure, which your thing, I judge, does not do. If you want to go ahead and give the thing a name it won't be any worse than what the distinguished Dr. Walcott did in the case of his so-called Pre-Cambrian algae. And he was director of the United States Geological Survey, Secreary of the Smithsonian Institution, and president of the National Academy of Sciences! So you would have a very eminent precedent. Your 'new species' would certainly be as good as his *Newlandia concentrica*."

Dr. Howe informed me that Professor A. C. Seward, Paleobotanist of Cambridge University, who is sceptical as to the organic nature of Cryptozoon, and thinks such concentric rings may be due to purely physical precipitation of minerals, was soon to lecture in New York. So when Dr. Seward appeared before the Torrey Botanical Club, and the department of botany of Columbia University in a lecture at Columbia not long after I put my problem to him. He was much interested, and after his return to England, wrote me for more photographs and actual specimens, which I sent him. He wrote: "I realize that the explanation of the curious structures known as Cryptozoon is one of the most difficult problems and that makes it all the more interesting to tackle."

I also applied to Professor Charles P. Berkey, head of the department of geology and mineralogy at Columbia University, for his views. Anderson and I had made further visits to the region where we first found the circles, and scoured the woods and ledges for a mile north and northeast of the original boulder, on the supposition that it had been transported by the ice of the continental glacier and that we might find its source in some ledge, not far off. We did not find such a ledge, but we did find at least twenty other glacial fragments, of the same quartzite in a fan-shaped area, northeast of Tock's Swamp from a few

pounds to a hundred pounds or more in weight, each showing more or less perfect rings. One of these was like a dumb-bell made of two of the circles, each three or four inches in diameter with six or eight rings strongly welded together, which appeared to have weathered out under glacial erosion or later disintegration of a larger boulder. This I sent to Dr. Berkey. He too was much interested, and also referred them to his associates, Dr. G. Marshall Kay and Mr. G. I. Atwater, who made thin sections. Dr. Kay reported that his conviction was that the specimens were of inorganic character. He wrote: "This is evident from the fact that the bedding in the rock passes directly through the spherical masses. The concentric spheres in the weathered specimens are due to the presence of layers about the center of the mass that are differently cemented, with the result that the more poorly cemented spherical layers have been more disintegrated than their adjacent better cemented layers. From a petrographic study of the sections, it seems that an original sandstone has been silica cemented, the cement being added as enlargement of grains. This cement has in turn been replaced in concentric zones about a central point by iron oxide, this replacement in some instances having also affected the original grains of sand. These iron-oxide cemented zones have disintegrated more readily than those in which the silica cement has not been replaced. The structures are most similar to concretions, though they differ from such structures in that the concentric banding is due to zonal replacement of the cement in a quartzite rather than to a zonal cementation of sandstone. In summary, the structures in the specimens of the Shawangunk quartzite are concretion-like structures that bear no evidence of organic origin."

Mr. Atwater's report was that the specimen showed bedded sedimentary original structure, with cementation by silicification, and replacement; that the grains were of quartz, probably originally from vein quartz; quartzite, and infrequent argillite, titanite and tourmaline, with chlorite as an alteration product formed partly after cementation and possibly partly introduced as inclusions in the quartz grains.

Dr. Berkey, expressing the same views as those of his associates, remarked:

"The specimens make a striking exhibit and are, to say the

least, unusual, especially for that kind of rock, and we have no adequate explanation for their development in this particular bed on such a large scale, for the formation as a whole, as far as I have seen it, is quite free from such structures. For the main question, however, we are confident that the forms are not organic."

I also sent photographs and specimens to Dr. Henry B. Kummel, State Geologist of New Jersey, in Trenton. His first reaction seemed to indicate a belief that they represented something other than an inorganic formation. He wrote:

"Although you found the specimen on top of Kittatinny Mountain, I am not absolutely certain that it is the Shawangunk sandstone, Mr. Johnson [his assistant] has succeeded in getting a slight lime reaction with a little acid. Since it is a drift boulder, it may have been derived from some distant source and may be some other formation than the Shawangunk. The concentric layers certainly look like a marine algal organism, perhaps Cryptozoon. At one or two points there are forms which look like Crinoid stems, but I am not at all sure that this is correct. At a number of points also I notice what seems to be somewhat definite indications of a cellular coralline structure. Some of the tubular holes look to me more like worm borings than cavities from which pebbles weathered out. Others, however, are unquestionably due to differential weathering. All in all, my guess is that the specimen was originally a sandstone bound together by calcareous cement and that some lime secreting organisms assisted in its formation. I believe that we have something more here than merely water-laid sand layers."

Upon hearing Professor Berkey's views, Dr. Kummel said he thought they were probably correct and that the material was not organic in origin. He referred to cone-in-cone structures in western calcareous shales, which had a striking resemblance to some of the V-shaped cross sections of the concentric markings of my specimens."

Well, here are the varying views on the subject. I still think, with all respect to these distinguished authorities who differ, that we may have some evidence of organic origin. Others have suggested the rings may be due to lime or silica secreting marine animals. Dr. Howe has described some unquestionable fossil algae with concentric circles and microscopic cell structure in

younger formations than the Silurian. Both vegetable and animal life existed in the Silurian seas, although no traces have been reported hitherto from the Shawangunk quartzite. Somewhere traces might have been left. I shall look for better material and more of it, to see if I cannot give this thing a name. Or, as Dr. Seward thinks, is there reason to doubt the algal origin of Cryptozoon? The likeness of the perfectly regular rings in the Shawangunk grit and in the Mohawk Valley limestone is certainly suggestive of regular deposition of lime or silica about a growing circular thallus of some large marine alga.

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